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CORRELATION BETWEEN MEASURED AMBIENT AIRBORNE PARTICULATE MATTER (PM10) CONCENTRATIONS AND OPHTHALMOLOGIC DISEASE, NON-BATTLE INJURY (DNBI) RATES IN ACTIVE DUTY PERSONNEL DEPLOYED TO A US MILITARY BASE IN CENTRAL COMMAND (CENTCOM) BETWEEN OCTOBER 1999 AND SEPTEMBER 2001

A PROJECT REPORT
SUBMITTED TO THE FACULTY OF
THE DEPARTMENT OF PREVENTIVE MEDICINE AND BIOMETRICS OF THE UNIFORMED SERVICES UNIVERSITY OF THE HEALTH SCIENCES
BY

MONICA U. SELENT, B.S., D.V.M.
MAJOR, BSC, USAF

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
MASTER OF PUBLIC HEALTH

PROJECT MENTOR:
ROBERT J. FITZ, COLONEL (Ret), U.S. Army
Assistant Professor, DPMB

JUNE 2004

CORRELATION BETWEEN MEASURED AMBIENT AIRBORNE PARTICULATE MATTER (PM10) CONCENTRATIONS AND OPHTHALMOLOGIC DISEASE, NON-BATTLE INJURY (DNBI) RATES IN ACTIVE DUTY PERSONNEL DEPLOYED TO A US MILITARY BASE IN CENTRAL COMMAND (CENTCOM) BETWEEN OCTOBER 1999 AND SEPTEMBER 2001

Abstract

Previous studies have suggested an association between ambient airborne particulate matter (PM10) concentrations and adverse ophthalmologic conditions. To determine a correlation between PM10 and Ophthalmologic Disease, Non-battle Injuries (DNBI), datasets currently available on active duty personnel deployed to a US military base in Central Command (CENTCOM) were collected and analyzed for the period between October 1999 and September 2001. Weekly averages of ophthalmologic, non-ophthalmologic, and total DNBI rates were compared to a weekly average PM10 concentration and Pearson's coefficients were calculated ($r = 0.00024$ with p value = 0.5, $r = 0.090$ with p-value = 0.239, and $r = 0.087$ with p-value = 0.246, respectively). The extremely low r coefficients indicate that there is no correlation between weekly average PM10 concentrations and weekly average Ophthalmologic Disease, Non-battle Injury Rates at this location. Two conclusions are suggested: (1) the PM10 was not at a sufficient or consistently high enough level to affect the eye, or (2) personnel may already be protecting their eyes by wearing sunglasses and goggles or staying indoors when weather conditions are very windy.

Submitted by: Selent, Monica U., Maj, USAF, BSC, USUHS, MPH Student Project Report, June 2004

Introduction/Background

A survey of the literature shows that very little information is available regarding the effects on the eye by ambient particulate matter with an aerodynamic diameter less than 10 microns (PM10) concentrations. Previous air pollution studies have measured air components (such as NO, NO2, O3, SO2, and particulate matter) and compared their concentrations to health outcomes (i.e., respiratory disease, asthma, and/or eye ailments) in various cities in France, Mexico, China, Japan, and India. (1), (2), (3), (4), (5), (6), (7), (8) A specific relationship between eye ailments and airborne particulate matter concentrations in these studies were either not analyzed or did not demonstrate a strong relationship. Just, et al, did show a relationship between eye irritation in asthmatic children with O3 levels and particulate matter (PM) in Paris, France. (1) Bourcier, et al, in another study in Paris, France, showed a strong relationship between conjunctivitis and air pollution measurements of NO2, maximum temperature, and wind speed. (2)

US troops sent to Kuwaiti during oil well fires in 1991, when questioned upon return to the US, reported more eye and respiratory ailments had occurred during their three-month mission in Kuwait than either before or after their deployment. Their symptoms were associated with their reported proximity to the oil fires and the incidence decreased after the soldiers left Kuwait. (9) Air concentration measurements within Kuwait, to include particulate matter, were not available for analysis in that study. Symptoms were presumed to be due primarily to the toxins released with the fires.

In the midst of windstorms or combat and without protection, the eye is expected to be vulnerable to serious injury from flying debris. A retrospective review of emergency departments

visits for ocular complaints was conducted by Heier, et al, at a combat support hospital during Operations Desert Shield and Desert Storm. (10) Ocular injury and/or disease accounted for 14% (108/767) of the emergency department visits. (The 108 patients included 13 Iraqi prisoners.) Corneal foreign bodies was the most common eye injury (17%). Blepharitis and conjunctivitis was the most common eye disease (14%).

At many US military locations in rural areas of Southwest Asia, PM10 concentrations are often due to the amount of sand blown into the air during windstorms. Medical planers might expect ophthalmologic DNBI rates to increase after periods of high PM10 concentrations. Ophthalmologic DNBI conditions would include physical eye damage (i.e., corneal abrasions) or infections (i.e., conjunctivitis) caused by sand and other particles blown into the eye. Blowing particulates can lead to eye irritation, which may cause individuals to rub or scratch their eyes, resulting in corneal abrasions or infections. Eye illnesses may limit duty performance, increase time lost away from work, and affect mission effectiveness.

If an association is found, further study could be conducted to determine if routine air sampling at deployed locations should be used by clinics to anticipate when patient visits for ophthalmologic DNBI's may increase. Clinics can plan ahead to ensure supplies and personnel are available, especially during seasons of the year when windstorms are more common. Medical personnel can educate troops and commanders on preventive measures. Line commanders can be pre-warned that a percentage of personnel may require medical attention after high PM10 concentrations and plan accordingly. If weather forecasting can predict when PM10 will increase, personnel protective measures can be implemented such as requiring personnel to wear eye protection or prohibiting non-mission essential outdoor activities during days with high PM10.

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The research question for this project asks whether or not there is a correlation between measured ambient airborne particulate matter (PM10) concentrations and ophthalmologic Disease, Non-battle Injury (DNBI) rates in active duty personnel deployed to a US military base in Central Command (CENTCOM) between October 1999 and September 2001. The null hypothesis is there is no association between average weekly PM10 and average weekly Ophthalmologic DNBI rates at this location during this time period.

Methods

This project is an ecologic study using secondary data analysis to compare the weekly average Ophthalmologic, the Non-ophthalmologic, and the Total DNBI rates (# cases per 1,000 personnel per week) against weekly PM10 concentration (mg per m3) measurements from Location A during the period of October 1999 to September 2001. The null hypothesis is that there is no correlation between average weekly PM10 concentrations and average weekly DNBI rates in U.S. active duty personnel deployed to a US military base in Central Command (CENTCOM) between October 1999 and September 2001.

Location A is a US military base situated in the CENTCOM area of operation. For security reasons, the US military location cannot be named or identified when the DNBI rates and PM10 data are combined. The location was selected due to the availability of datasets for both weekly DNBI rates and a weekly measurement of PM10 concentrations over a 2-year period. A two year period was sought to account for seasonal variances. Missing observations were present in both datasets, but 65 weeks over the two year period contained both an average DNBI rate in the same week as a PM10 concentration measurement. Other CENTCOM locations were considered, with the goal of finding a location away from a large industrial area which might confound the analysis with industrial air pollutants; however, datasets for either the

DNBI rates or PM10 concentrations were unavailable for other locations, or the data quantity or quality was not sufficient for this study.

Given the difficulty in finding more that one study site that contained both datasets, a control population for comparison was not possible. Ideally, a control population would have a similar base population and activities, but located in an area with low to zero PM10 concentrations over the same time period.

The weekly DNBI rates were supplied by the Air Force Institute for Operational Health (AFIOH) using archived data. Only the calculated rates (# of cases per 1000 personnel per week) were supplied to the investigator. The investigator cannot identify actual cases counts, denominator (troop strength), nor individual human subjects (directly or by encoded identifiers) from the datasets provided by AFIOH. One assumption for this study, with the DNBI dataset, is that personnel are equally susceptible to ophthalmologic DNBI at anytime during their deployment. In other words, personnel do not develop a change in resistance or susceptibility to eye conditions, caused by PM10, as he/she accumulates more time on station. At Location A, most personnel were deployed for 12-month periods with few repeated deployments for any individual.

The DNBI data was collected at Location A using only outpatient visits at the medical clinics and included only new cases (incidence rates) of acute disease. Examples of an ophthalmologic DNBI would be a corneal abrasion or acute viral conjunctivitis. A chronic disease, such as diabetes-associated cataracts, would not be categorized as a DNBI. Weekly DNBI rates were calculated at Location A. DNBI rates do not count any patient's follow-up visits for the same diagnosis documented by an earlier visit. The criteria for DNBI calculations were set by JCS Memorandum, MCM-251-98, "Deployment Health Surveillance and

Readiness", 4 December 1998.

The PM10 concentration data (mg/m3) was supplied by US Army Center of Health Promotion and Preventive Medicine (USACHPPM). PM10 samples were collected (over a 24 hour period) weekly at Location A. Samples were analyzed and documented in the field. The results of the field samples were forwarded to USACHPPM and recorded electronically. Over the two year period, the frequency that air samples were collected each week varied during different months. Over different groups of months, air samples were collected every three, five, or seven days or with no discernable pattern. To correspond to the Sunday through Saturday average DNBI rates, PM10 concentrations for air samples that fell between Sunday through Saturday of the same week were calculated by the investigator into a weekly average.

The timeframe for the project analysis sought to include only data prior to 2003 in order to exclude the build up of military forces occurring in CENTCOM in the spring of 2003. The base population is used in the denominator of the DNBI rate calculations. Historically, it can be difficult to get an accurate base population on a weekly basis. A small percentage of personnel are constantly arriving and departing daily. A sudden or large influx of personnel in the spring of 2003 may have been difficult for the medical technicians, who were calculating DNBI rates, to track on a weekly basis. In addition, the incoming troops may not have stayed at Location A for very long and potentially classified troop movements would not be quickly reported to the medical clinic.

Statistical analysis was conducted using simple linear regression to determine if ophthalmologic DNBI rates are correlated with PM10 concentrations. Since data was collected over time, the assumption in correlation and regression that the variables are independent observations may be violated. Residual plots were examined for evidence of autocorrelation.

Analysis consisted of PM10 vs. Ophthalmic DNBI, PM10 vs. Total overall DNBI, and PM10 vs. Non-ophthalmic DNBI (total DNBI rate minus the ophthalmic DNBI rate). The purpose of looking at the non-ophthalmic DNBI rate was to determine whether an ophthalmic DNBI-PM10 relationship is occurring independent of the overall DNBI rate. If a relationship existed between ophthalmic DNBI and PM10, the non-ophthalmic DNBI rate was expected to be less susceptible to change with a change in PM10 concentrations. The analysis quantified the association between the PM10 and DNBI rates using Pearson correlation. The p-value (alpha) was set at 0.05 and Beta at 0.20 to minimize Type I and Type II errors. At this level, a sample size of at least 47 weeks (of DNBI rates with PM10 data) was needed to detect a significant association if the true correlation coefficient (r) was at least 0.40. The dataset had 65 weeks of corresponding DNBI and PM10 data. SPSS was used as the statistical analysis software. At the 5% significance level, if the r coefficient was equal to or less than 0.40, the null hypothesis would fail to be rejected.

Results

The DNBI dataset had 66 weeks of weekly average rates. For the PM10, there were 265 air samples that were calculated into 77 weeks of PM10 weekly averages. There were 65 weeks in which both DNBI and PM10 data were available in the same Sunday to Saturday period between 24 October 1999 and 23 September 2001. Table A shows the ranges and means for the various datasets.

The average weekly Ophthalmologic DNBI ranged from 0.0 to 5.61 cases with a mean of 1.7 new cases per week and a standard deviation of 1.45. There were 17 weeks in which the average Ophthalmologic DNBI was reported as 0.0. The average weekly Total DNBI ranged from 12.2 to 116 cases with a mean of 62.2 new cases per week and a standard deviation of 22.2.

The average weekly Non-ophthalmologic DNBI ranged from 11.1 to 114 cases with a mean of 60.5 new cases per week and a standard deviation of 21.5.

The average weekly PM10 concentrations ranged from 25.86 to 535.96 mg per m3 with a mean of 119.9 mg per m3 and a standard deviation of 103.4. Approximately 85% of the weekly PM10 averages were below 200 mg per m3. In Graph 1, a seasonal variation of PM10 appears. From January through mid summer, the average concentration has an upward trend which matches the common occurrence in the area that severe windstorms happen in the spring. The Total and Non-ophthalmologic DNBI averages also show an upward trend in the spring, that decreases again over summer and fall (Graph 2 and 3). There was no noticeable seasonal variation in the Ophthalmologic DNBI averages (Graph 4).

The results of the regression analysis showed no correlation between average weekly PM10 concentrations and weekly DNBI rates. When comparing the ophthalmologic DNBI to PM10, the Pearson correlation (r coefficient) equaled 0.000021 with a significance p-value of 0.5. A scatter graph of the residuals shows almost equal distribution. (Table B and Graph 5)

The regression analysis between PM10 and Non-ophthalmologic DNBI has a Pearson correlation of 0.090 with a p-value of 0.239. A scatter graph of the residuals shows almost equal distribution. (Table C and Graph 6)

The regression analysis between PM10 and Total DNBI has a Pearson correlation (R coefficient) equal to 0.087 with a p–value of 0.246. A scatter graph of the residuals shows almost equal distribution. (Table D and Graph 7)

Given the lack of correlation, it was not necessary to evaluate for autocorrelation over time.

Discussion:

The project attempted to analyze the association between an average weekly DNBI rate and an average weekly PM10 concentration. The expectation by a casual observer is that as the sand and dust PM10 concentrations increase, the number of ophthalmologic conditions would increase, too, due to irritation, foreign body injury, and increased susceptibility to infection. As mentioned in the introduction, there are few studies available that statistically evaluate that assumption. This study makes one of few attempts to statistically compare acute ophthalmologic DNBI rates with environmetal PM10.

Given the type of datasets used in this study, there are numerous opportunities for bias, confounding, and lack of randomness to occur. Bias could have been introduced in the data collection and analysis over the two year period.

For observation bias, it is unknown what was the level of training and experience of the personnel collecting and reporting the DNBI cases and how many conducted the task. The likelihood for error can be expected to increase as the number of personnel, level of training, and the consistency of performing the task changes from person to person. The clinicians also play a vital in annotating the diagnosis effectively for the case to be recognized and included as a DNBI case. Since the original cases cannot be identified, it is unknown if all appropriate incidence cases were categorized per the JCS memorandum or whether follow-up visits may have been accidentally counted as new cases. There were 17 weeks from the 65 observations with an ophthalmologic DNBI rate of 0.0. Was this a true number or was it simply not recorded during these weeks due to lack of training or other cause?

Determining the PM10 concentrations relies on the training and experience of the technician who performs the air sampling task to use the equipment appropriately and make the correct calculations. The location of where the air samples were collected, such as near or far

from work or housing sites, could introduce observation bias, as well. The closer the air samples were collected to human activity, the more likely an accurate exposure was documented.

In terms of bias in the data analysis, the DNBI rates were calculated at the location and it is unknown what was the level of training and experience of the personnel who performed this task over the two year period. The source of the base population number and how often it was verified is unknown. The actual clinical diagnoses used to determine the numerator and the base population at risk is not available from this location to verify the accuracy of the rates.

The PM10 concentrations sent to USACHPPM usually included the raw data needed to make the daily concentrations. However, error could have been introduced in this study project since the frequency of air sample collections were not consistent. Over the two year period, air samples were collected at differing intervals during various time periods, although most often at three, five, or seven days intervals. With this inconsistency, data for a weekly average PM10 concentration may include anywhere from one to nine individual air samples.

Even if all the ophthalmologic DNBI cases were correctly identified, this project was not designed to include confounders such as environmental factors (for example, humidity or chemical concentrations in the air) that may affect eye health. Outbreaks of any infectious conjunctivitis (for example, "pink eye"), or lack of such occurrence, and training about eye protection given to the base population was not documented. Occupations present on the base were not considered. There may have been at this location more or less job categories requiring eye protection that affected the number of eye injuries that occurred.

Although 65 weeks of observations should be sufficient for randomness, the inconsistency of how often the PM10 samples were collected may not have been a random occurrence. For example, there may have been less collections if the windstorms were high and

discouraged personnel to travel to the collection sites.

Another weakness in this study is that only one location could be identified and a control population for comparison is lacking. All CENTCOM locations should have been collecting PM10 and DNBI data during the time period of this study and sending it to the appropriate agencies. However, the data source agencies (USACHPPM and AFIOH) could more easily provide information from a location belonging to their own service than from a site belonging to a different service. Although beyond the scope of this project to determine, computer systems are one possible difficulty for the locations to overcome when sending data to another service agency or for the agencies when receiving and storing data originating from another service.

This project focused on acute ophthalmologic diseases seen as an outpatient visit at Location A. Since no individual identifiers are used, the study does not evaluate any long-term chronic conditions that may have evolved due to a deployment at this location.

Given that only one location was included, the level of bias is unknown, and control for confounders is lacking, the study is not considered to be generalizable to a larger population beyond the U.S. personnel who were at this location during the specified time period.

Conclusions

Despite the shortcomings of the available data as mentioned in the discussion and given the extremely low correlation values, the conclusion is that the null hypothesis cannot be rejected. There is no correlation between average weekly PM10 concentrations and average weekly ophthalmologic DNBI rates at this CENTCOM location.

One reason for the lack of correlation may be that the PM10 concentrations at this particular location were not at a sufficient or consistently high enough level to affect the eye. Further research should consider focusing on the search for a PM10 concentration threshold

and/or duration above which ophthalmologic conditions can be correlated statistically. Daily air samples, collected in close proximity to the human subjects, would increase the accuracy of the exposure measurements.

Studies should look at other environmental factors, such as humidity or chemical air concentrations that may be associated to ophthalmologic DNBI rates.

Personnel may be already protecting their eyes because of occupational required personnel protective equipment. Personnel may also be employing common sense by wearing sunglasses and goggles or staying indoors when weather conditions are very windy. Additional studies should try to determine if a subset of personnel within the base population are more susceptible (for example, contact wearers), whether acclimatizing occurs and PM10-related eye problems appear more frequently shortly after arrival, and/or the impact of eye protection usage and training for new arrivals. The chronic effect on the eyes due to the exposure of high PM10 concentrations is another potential study.

This study also re-enforced to the investigator the value of collecting data for a purpose. Electronic databases have certainly improved the amount and efficiency in which data can be collected, stored, retrieved, and analyzed. This study would not have been possible without those databases. The indiscriminate collection of data, however, without a goal (or good study question), can result in the omission of important variables needed for analysis and risks that the data will be un-interpretable. In addition, since specific military services are responsible for maintaining data originating from many DoD services, every effort should be made to ensure the data can easily be sent, stored, and retrieved between services, as needed.

Contributors

The investigator would like to thank Robert J. Fitz, COL (Retired), USA, USUHS, for his contributions and needed advise as the project advisor, and Ms. Cara Olsen's invaluable assistance with the data analysis.

Acknowledgements

The author would like to acknowledge the assistance of Dr Arthur Lee and Mr Mark Walter from USACHPPM and Maj Brad Winterton and Maj Renee Shibukawa-Kent from AFIOH for providing the PM10 and DNBI datasets, as well as, USUHS professors COL Robert Lipnick, USA, and Col Martha Turner, USAF, for providing input and recommendations in the course of this project. The investigator would also like to thank the nameless technicians in the field who, years ago, collected and reported the data used in this study.

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Appendices:

A. IRB Approval
B. AFIOH Approval
C. Tables A - D
D. Graphs 1 - 7

Appendix A. IRB Approval

UNIFORMED SERVICES UNIVERSITY OF THE HEALTH SCIENCES
F. EDWARD HEBERT SCHOOL OF MEDICINE
4301 JONES BRIDGE ROAD
BETHESDA, MARYLAND 20814-4799

Notice of Project Approval
Original

Protocol Information:

Project Number:	**T087UW-01**
Principal Investigator:	**Monica U. Selent**
Department	PMB - Preventive Medicine and Biometrics
Sponsor:	Uniformed Services University of the Health Sciences
Project Type:	USUHS - Dissertation Awards
Title:	**Correlation Between Measured Ambient Airborne Particulate Matter (PM10) Concentrations and Ophthalmologic Disease, Non-Battle Injuries (DNBI) . .**
Project Period:	02/13/2004 - 06/30/2004
Activity Period:	02/13/2004 - 06/30/2004

Assurance and Progress Report Information:

Name	Sup. 0	Approval Type	Status	Approved On	Due Date	Forms Rcvd
Progress Rpt	0	Final	To be submitted		06/30/2004	N/A

Remarks:

This Notice of Project Approval establishes that the Office of Research has reviewed and approved your project.

Please Note: Upon completion of your project a final Progress Report (USU Form 3210) must be sumitted to the Office of Research.

I have reviewed the project described above and approve the research for this project. However, this action does not imply that the appropriate assurances have been obtained nor should work begin on this project until all appropriate assurances are obtained. No funding is provided for this activity period.

Questions regarding this award should be directed to Sheila J. Dudley at 301-295-9818 in the Office of Research.

Steve Kaminsky

Steven G. Kaminsky
Vice President for Research
Uniformed Services University of the Health Sciences

cc: Gerald V. Quinnan Jr.
File

Appendix B. AFIOH Approval

DEPARTMENT OF THE AIR FORCE
AIR FORCE INSTITUTE FOR OPERATIONAL HEALTH (AFMC)
BROOKS CITY-BASE, TEXAS

28 January 2004

MEMORANDUM FOR DIRECTOR, HUMAN SUBJECTS RESEARCH PROTECTIONS PROGRAM
ATTN: Dr Bienvenu
Uniformed Services University of the Health Sciences
4301 Jones Bridge Road
Bethesda, MD 20814

FROM: AFIOH/RSRH
2513 Kennedy Circle
Brooks City-Base TX 78235-5116

SUBJECT. Authorization for Use of Existing Data

1. The Air Force Institute for Operational Health (AFIOH) authorizes Maj Monica Selent, USAF, and MAJ Michael Bonhage, USA, to use AFIOH-supplied data in their independent projects in partial fulfillment of the requirements for Master of Public Health degree at the Uniformed Services University of the Health Sciences, Department of Preventive Medicine and Biometrics.

2. Data will be provided directly to Maj Selent and MAJ Bonhage in electronic format and will consist of weekly aggregate disease and non-battle-injury (DNBI) rates from two locations within US Central Command--[redacted], and [redacted]-during the time period October 1999-February 2002. The specific weekly DNBI rates provided will be respiratory, ophthalmologic, and total DNBI. The rates will not include actual case counts, denominator (troop strength) data, or any patient identifiers.

3. Maj Selent and MAJ Bonhage are authorized to review and analyze this data according to the design of their proposed projects. Maj Selent's project involves investigating the possible association between ambient airborne particulate (PM10) concentrations and ophthalmologic rates at [redacted] and [redacted] MAJ Bonhage's project will focus on the potential association between PM10 concentrations and respiratory rates at these locations.

4. Any questions or comments, please contact me at DSN 240-6030 or brad.winterton@brooks.af.mil.

Brad S Winterton

BRAD S WINTERTON, Major, USAF, BSC
Epidemiology Consultant

Note: As indicated on Page 3, the CENTCOM location cannot be named.

Appendix C. Tables

Table A. Frequency Statistics of DNBI and PM10 Environmental Data

Statistics

		OPHTHO	NONOPH	TOTAL	ENVIRON
N	Valid	66	66	77	77
	Missing	141	141	130	130
	Study Size	65	65	65	65
Mean		1.7194	60.9095	62.9360	117.0179
Median		1.2185	61.9450	62.8780	92.0100
Mode (a)		.00	46.67	40.00	11.78
Std. Deviation		1.51715	21.55678	22.13262	98.74193
Variance		2.30174	464.69464	489.85282	9749.96969
Range		5.61	103.06	104.58	524.18
Minimum		.00	11.11	12.22	11.78
Maximum		5.61	114.17	116.80	535.96

a Multiple modes exist. The smallest value is shown

Table B. Correlations between Ophthalmologic DNBI Rates and PM10 Environmental Data

		OPHTHO	ENVIRON
Pearson Correlation	OPHTHO	1.000	.0000214
	ENVIRON	.0000214	1.000
Sig. (1-tailed)	OPHTHO	.	.500
	ENVIRON	.500	.
N	OPHTHO	65	65
	ENVIRON	65	65

Table C. Correlations between Non-ophthalmologic DNBI Rates and PM10 Environmental Data

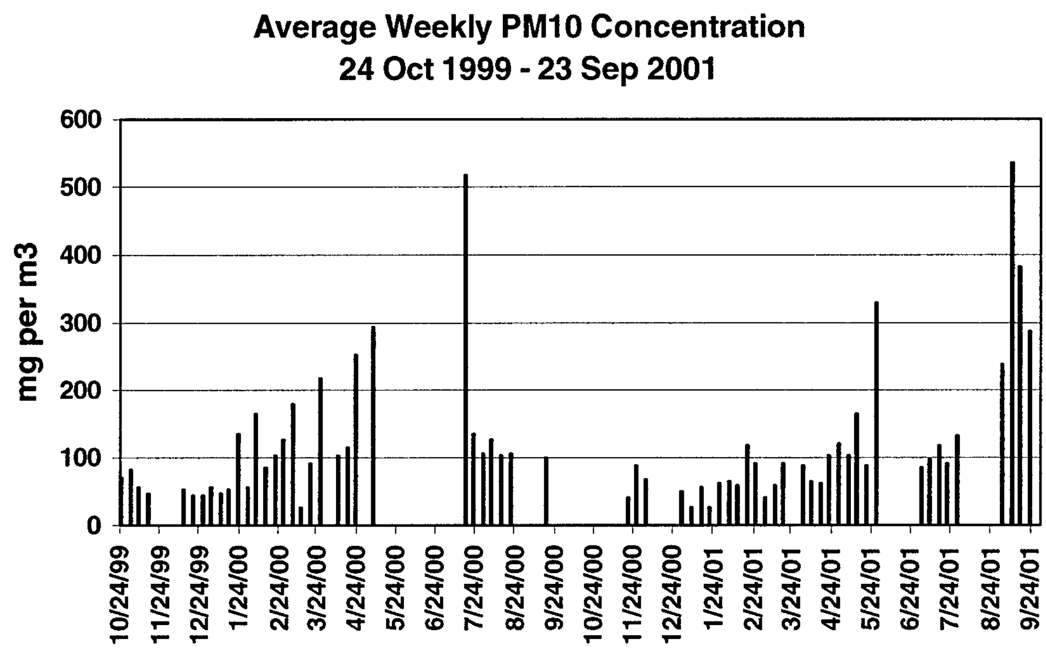
		NONOPH	ENVIRON
Pearson Correlation	NONOPH	1.000	.090
	ENVIRON	.090	1.000
Sig. (1-tailed)	NONOPH	.	.239
	ENVIRON	.239	.
N	NONOPH	65	65
	ENVIRON	65	65

Table D. Correlations between Total DNBI Rates and PM10 Environmental Data

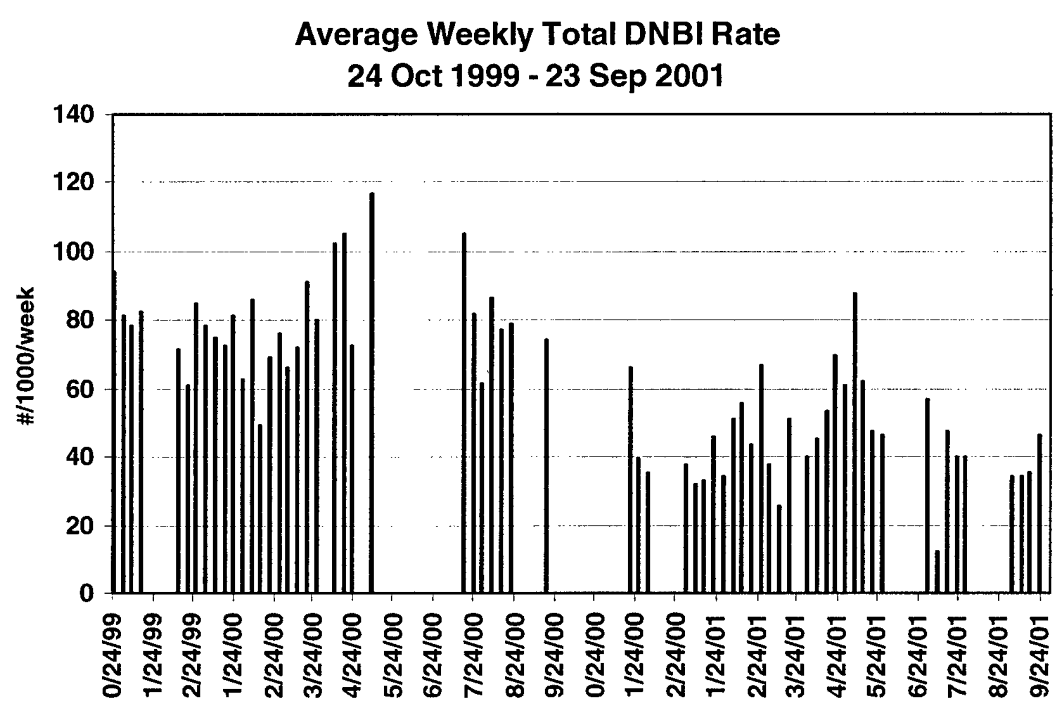
		TOTDNBI	ENVIRON
Pearson Correlation	TOTDNBI	1.000	.087
	ENVIRON	.087	1.000
Sig. (1-tailed)	TOTDNBI	.	.246
	ENVIRON	.246	.
N	TOTDNBI	65	65
	ENVIRON	65	65

Appendix D. Graphs

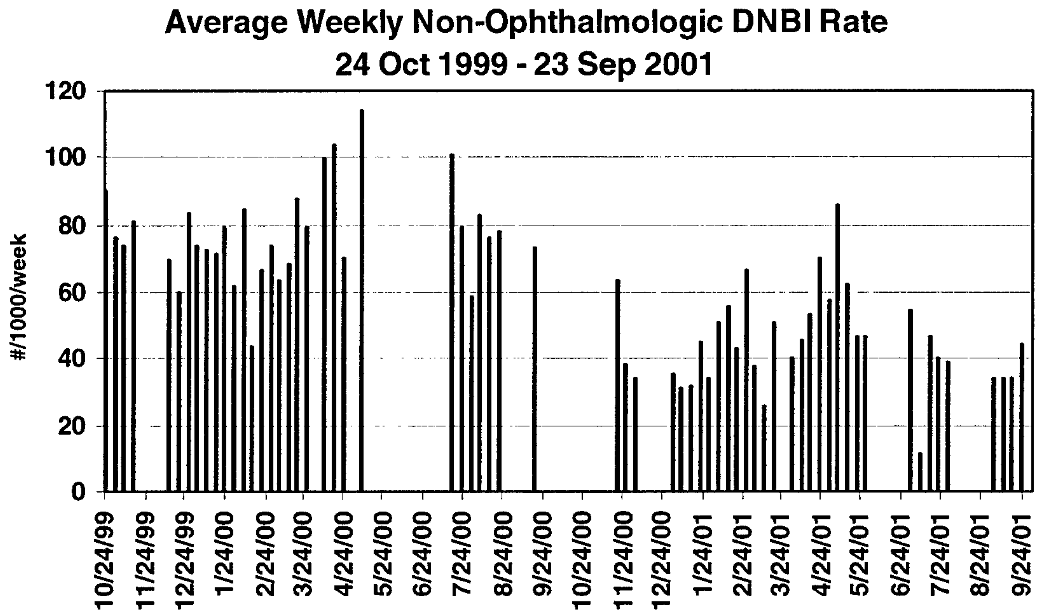
Graph 1. Average Weekly PM10 Concentration



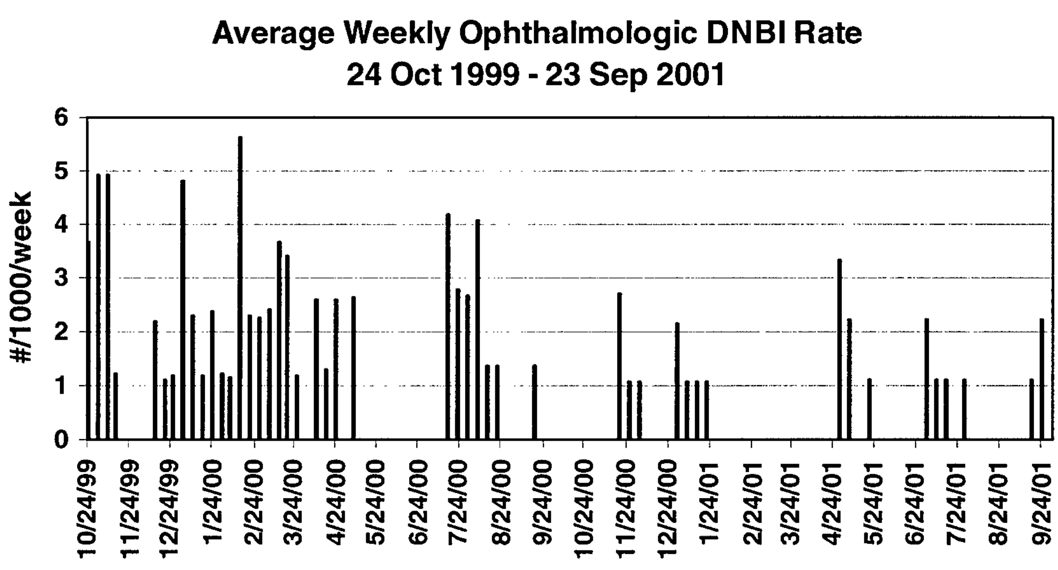
Graph 2. Average Weekly Total DNBI Rate



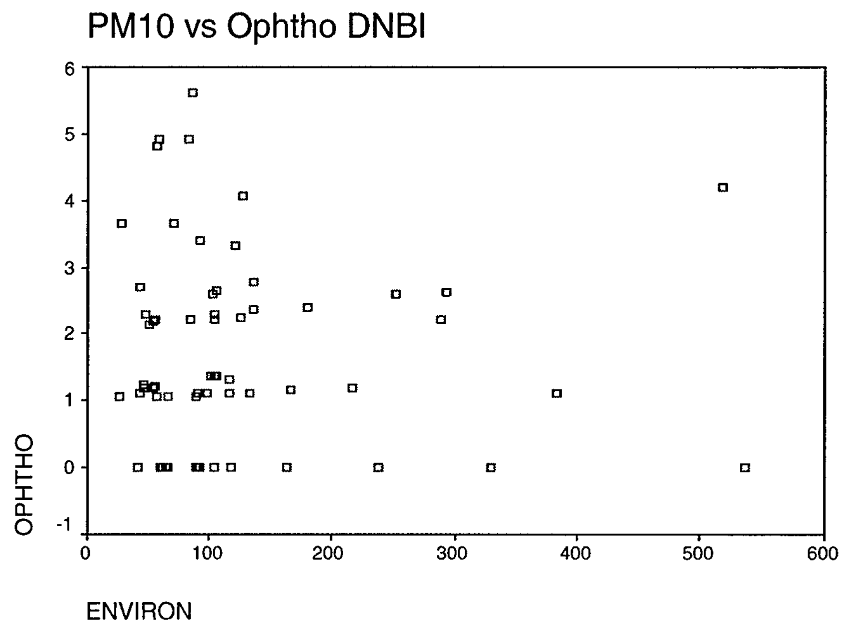
Graph 3. Average Weekly Non-Ophthalmologic DNBI Rate



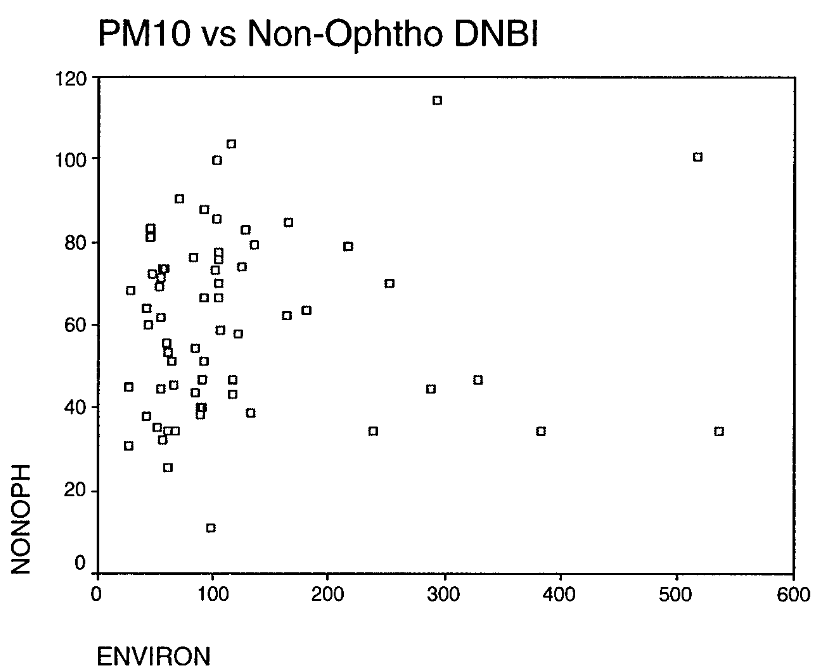
Graph 4. Average Weekly Ophthalmologic DNBI Rate



Graph 5. Scatterplot of PM10 Environmental Data and Ophthalmologic DNBI Rates



Graph 6. Scatterplot of PM10 Environmental Data and Non-Ophthalmologic DNBI Rates



Graph 7. Scatterplot of PM10 Environmental Data and Total DNBI Rates